CONFERENCE ON DISARMAMENT

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LETTER DATED 19 FEBRUARY 1991 FROM THE PERMANENT REPRESENTATIVE OF AUSTRIA ADDRESSED TO THE SECRETARY-GENERAL OF THE CONFERENCE ON DISARMAMENT TRANSMITTING THREE STUDIES RELATED TO THE VERIFICATION OF CHEMICAL WEAPONS

I have the honour to forward to you enclosed copies of three studies related to CW-verification, named: (1) "Materials monitoring in the control of chemical weapons' and narcotic drugs' precursors", (2) "Development of a computer program for accounts auditing during inspections of facilities", (3) "A Program for Checking Stock Records for Consistency", which were elaborated by Austrian experts, members of the so-called "Austrian Scientific Council for CW-verification".

The paper "Materials monitoring in the control of chemical weapons' and narcotic drugs' precursors" attempts to identify areas of the verification régime adopted under the NDC which seem principally applicable also in the CW-context.

The two papers entitled "Development of a computer program for accounts auditing during inspections of facilities" and "A Program for Checking Stock Records for Consistency" identify the basic structure for a computer-based program for verification of financial and material records in its theoretical as well as practical dimensions. The computer program in form of a floppy disc can be made available to interested delegations.

I would be grateful if the above-mentioned documents could be circulated as an official document on the Conference on Disarmament.

(Signed) Franz Ceska
Ambassador and
Permanent Representative
to the Conference on
Disarmament

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MATERIALS MONITORING IN THE CONTROL OF CHEMICAL WEAPONS AND NARCOTIC DRUGS' PRECURSORS

Since a number of years, efforts to negotiate a Convention on Chemical Weapons are being made which aim at the prevention of the production of such weapons. One of the main problems encountered during these negotiations is that of the verification of the non-production of chemical weapons. As most of these chemical weapons can be produced in plants producing standard chemicals for commercial use, the prohibition of facilities for the production of chemical weapons is not sufficient. Verification of non-production has to be aimed at earlier stages of the production process: it will have to prove that materials and installations that could be used for the production of chemical weapons are used for permitted purposes only. Considerable efforts during the negotiations of the Convention were conducted toward assuring an effective verification of non-production of Schedule 2 chemicals through on-site inspection of dual-purpose facilities.

In 1988 the United Nations adopted a Convention Against Illicit Traffic In Narcotic Drugs and Psychotropic Substances. Whereas in this Convention trade in common chemical intermediates, which are required for the production of drugs (precursors), is closely monitored, the Convention on Chemical Weapons requires for common chemical intermediates used in the production of chemical weapons reporting of data concerning imports, exports, production and consumption on a national basis only. No monitoring of the trade of these chemicals is required.

It is proposed that for chemical weapons' precursors a trade monitoring system should be established consisting of three interlocking control régimes:

- a facility control régime;)
- a national control régime;) forming together the domestic control régime
- an international control régime.

The basis for the national and for the international control régimes is the facility control régime as the latter is based on the data of the former. So the primary effort must be directed towards developing a facility control régime that is generally applicable, requires a minimum of effort and no undue intrusion into the internal affairs of the company concerned, but assures a maximum of confidence in its results. In order to achieve the requirements mentioned above an effective facility control régime based on auditing various company records by a computerized procedure was developed. At a later stage this program will be extended to allow monitoring trade in precursor chemicals on a national and on an international level.

Alfred Schmidt

MATERIALS MONITORING IN THE CONTROL OF CHEMICAL WEAPONS' AND NARCOTIC DRUGS' PRECURSORS

1. Introduction

Since a number of years efforts to negotiate a Convention on Chemical Weapons are being made which aim at the prevention of the production of such weapons. One of the main problems encountered during these negotiations is that of the verification of the non-production of chemical weapons.

As most of these chemical weapons can be produced in plants producing standard chemicals for commercial use, the prohibition of facilities for the production of chemical weapons is not sufficient. Verification of non-production has to be aimed at earlier stages of the production process: it will have to prove that materials and installations that could be used for the production of chemical weapons are used for permitted purposes only.

These ideas have found their way into the draft of the Convention: Article VI of the rolling text of the Convention on Chemical Weapons at present reads as follows:

"...

2. Toxic chemicals and their precursors listed in Schedules 1, 2A, 2B and 3 in the Annex on Chemicals which could be used for purposes prohibited by the Convention, as well as facilities which produce, process or consume these toxic chemicals or precursors, shall be subject to international monitoring as provided in Annexes 1, 2 and 3 to this Article.

...

4. Each State Party shall make an annual declaration regarding the relevant chemicals in accordance with Annexes 1, 2 and 3 to this Article ...

6. Each State Party undertakes to subject chemicals listed in Schedule 2, parts A and B and facilities declared under Annex 2 to this Article to monitoring by data reporting and routine systematic international on-site verification, through on-site inspection and use of on-site instruments as long as production and processing are not impaired.

7. Each State Party undertakes to subject chemicals listed in Schedule 3 and facilities declared under Annex 3 to this Article to monitoring by data reporting ..."

From this text it appears that two - interconnected - ways for verification procedures are envisaged:

- control of certain chemicals;

- control of certain facilities.

Both ways have advantages and disadvantages.

2. Control of facilities

Considerable efforts during the negotiations of the Convention were conducted towards assuring an effective verification of non-production of Schedule 2 chemicals through on-site inspection. General rules governing inspections were worked out as the importance of this aspect was recognized.

The following types of verification measures for Schedule 2 chemicals were considered:

- routine inspections
- ad hoc inspections
- challenge inspections.

According to Article VI of the Convention each State party has initially to prepare and present a list of facilities which, during any of the previous three calendar years, produced, processed, or consumed more than one ton of chemicals listed in Schedule 2, part A. Relevant non-prohibited activities of the chemical industry are verified by way of graded verification régimes subjecting chemicals listed in Schedules and the facilities producing or consuming such chemicals to systematic international on-site verification on a routine basis. Only a very limited number of facilities actually produce or consume the chemicals listed in the Schedules and would thus be declared. But the production of chemical weapons would be possible in a large number of other, undeclared facilities and so escape verification.

So as a complement the concept of "challenge inspections" was developed. In order to satisfy itself of the compliance of other State parties, each State party may enter into consultations with other State parties, request the Organization of the Chemical Weapons Convention to assist in clarifying any situation regarding compliance or it may request that a short-notice challenge inspection be conducted by the Organization anywhere and at any time in another State party. So challenge inspections are not limited to declared facilities. As most countries want to protect sensitive installations there is still no agreement about the issues of access to be granted and the permissible measures and procedures in challenge inspections.

In recent negotiations the concept of ad hoc inspections was proposed by a number of countries. This concept has been designed as a routine measure at the disposal of the Organization. It is restricted to all relevant production facilities of the chemical industry, which, according to a definition to be agreed upon, each State party would have to list in a "national register". From this register the Technical Secretariat would select at random facilities to be inspected in an unobtrusive manner. The sole purpose of these inspections would be to ascertain whether, at the time of the inspection, any chemicals listed in the Schedules of the Convention and unaccounted for in the declarations of the country are being produced or processed. It was also proposed to limit the number per year of ad hoc inspections in any country.

The state of the discussion has recently been described in detail by R. Lüdeking, Verifying a Chemical Weapons Convention, Chem. Weapons Conv. Bull. No. 9, September 1990.

From this discussion it appears that there are still considerable differences in the views of the negotiating countries.

3. Control of chemicals

It is also apparent that in the control of certain chemicals of great industrial importance the interests of the chemical industries will have to be taken into account.

The ad hoc group on trade control of the European Federation of Chemical Manufacturing Associations (CEFIC) in a recent (15 October 1990) statement gives the industry's view of the trade control problem of chemical weapons' precursors:

> "... the political need exists for Governments to control the trade in chemical weapons' precursors, but the practicabilities in achieving this without imposing unbearable constraints on the chemical industry are difficult to achieve. Hence the industry's preference for clear, transparent rules directed towards the identification and monitoring of suppliers and customers rather than an ever-growing list of controlled products. Organic chemists will always have the skill to circumvent the control regulations based upon a fixed list of chemicals ... . Chemical weapons' precursor legislation should conform to the same general principles as that for drug chemicals and, most recently, the legislation on the embargo on trade with Iraq".

So it will prove helpful to compare the control and monitoring systems of the Convention on Chemical Weapons and the Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances.

3.1 Control of chemicals in the Convention on Chemical Weapons

For the purpose of the Convention on Chemical Weapons, chemicals important as chemical weapons or for their production have been identified.

In the Annex on Chemicals Schedule 1 chemicals are defined as chemical weapons. For Schedule 2, part A and B, and Schedule 3 chemicals the following guidelines are given:

> "The following criteria shall be taken into account in considering whether a precursor to a Schedule 1 chemical would be included in Schedule 2, part A:
>
> 1. It may be used in one of the chemical reactions at the final stage of formation of a chemical listed in Schedule 1.
>
> 2. It may pose a significant risk to the objectives of the Convention by virtue of its importance in the production of a chemical listed in Schedule 1.

3. It is not produced in large commercial quantities for purposes not prohibited by the Convention.

Guidelines for Schedule 2, part B:

Super-toxic chemicals and other chemicals which are not included in Schedule 1 and are not precursor chemicals but which are deemed to pose a significant risk to the objectives of the Convention.

Guidelines for Schedule 3

The following criteria shall be taken into account when considering whether a dual-purpose chemical or a precursor chemical, not listed in other Schedules, would be included in Schedule 3:

A. Dual-purpose chemical

1. It is produced in large commercial quantities for purposes not prohibited by the Convention, and

2. it has been stockpiled as a chemical weapon, or

3. it may pose a risk to the objectives of the Convention by virtue of its physical, chemical and toxicological properties being similar to those of chemical weapons.

B. Precursor chemical

1. It is produced in large commercial quantities for purposes not prohibited by the Convention, and

2. it may pose a risk to the objectives of the Convention by virtue of its importance in the production of one or more chemicals listed in Schedule 1, or in the production of precursors to such chemicals, and

3. it contributes one or more atoms other than hydrogen, carbon, nitrogen or oxygen to the final listed end-product".

At present Schedule 2, part A lists 11 substances, Schedule 2, part 2 lists 1 substance and Schedule 3, 10 substances and 1 group of substances. Whereas the Schedule 2 chemicals are of minor commercial importance, Schedule 3 chemicals are important intermediates for many other products:

- phosgen
- cyanogen chloride
- hydrogen cyanide
- trichloronitromethan (chloropicrin)
- phosphorus oxychloride
- phosphorus pentachloride

- phosphorus trichloride

- di- and trimethyl- and ethyl-esters of phosphorus (III) acid

- sulphur monochloride

- sulphur dichloride

- thionyl chloride

There also exists a list of precursor chemicals proposed by the Australian group which contains 50 substances; it is mainly an elaboration of the lists in the schedules of the proposed Convention.

Annex 2 to Article VI of the present rolling text of the Convention requires for Schedule 2 chemicals:

> "The Initial and Annual Declarations to be provided by a State party under paragraphs 3 and 4 of Article VI shall include:
>
> DECLARATIONS
>
> 1. Aggregate national data on the production, processing and consumption of each chemical listed in Schedule 2, and on the export and import of the chemicals in the previous calendar year with a specification of the countries involved ..."

Information on facilities producing or consuming these chemicals is only required when these facilities produce, or have produced, chemical weapons.

Annex 3 to Article VI of the present rolling text of the Convention requires for Schedule 3 chemicals:

> "DECLARATIONS
>
> 1. The Initial and Annual Declarations to be provided by a State Party under paragraph 4 of Article VI shall include the following information for each of the chemicals listed in Schedule 3:
>
> ...
>
> (ii) The total amount produced, processed, consumed, imported and exported in the previous calendar year, whenever such an amount is above 30 tonnes ...

Further information is required for facilities using Schedule 3 chemicals for chemical weapons purposes. No monitoring of the trade of Schedule 2 or 3 chemicals is required.

3.2 Control of precursor chemicals in the Convention Against Illicit Traffic of Narcotic Drugs and Psychotropic Substances.

On 19 December 1988 the United Nations adopted a Convention Against Illicit Traffic In Narcotic Drugs And Psychotropic Substances. Article 12 of this Convention has the following wording:

"Substances frequently used in the illicit manufacture of narcotic drugs or psychotropic substances.

1.The Parties shall take the measures they deem appropriate to prevent diversion of substances in table I and II used for the purpose of illicit manufacture of narcotic drugs or pyschotropic substances, and shall co-operate with one another to this end.

....

8. (a) Without prejudice to the generality of the provisions contained in paragraph 1 of this article and of the provisions of the 1961 Convention, the 1961 Convention as amended and the 1971 Convention, the Parties shall take the measures they deem appropriate to monitor the manufacture and distribution of substances in Table I and Table II which are carried out within their territory.

(b) To this end, the parties may:

(i) Control all persons and enterprises engaged in the manufacture and distribution of such substances;

(ii) Control under licence the establishment and premises in which such manufacture or distribution may take place;

(iii) Require that licensees obtain a permit for conducting the aforesaid operations;

(iv) Prevent the accumulation of such substances in the possessions of manufacturers and distributors, in excess of the quantities required for the normal conduct of business and the prevailing market conditions.

9. Each party shall, with respect to substances in Table I and Table II, take the following measures:

(a) Establish and maintain a system to monitor international trade in substances in Table I and Table II in order to facilitate the identification of suspicious transactions. Such monitoring systems shall be applied in close co-operation with manufacturers, importers, exporters, wholesalers and retailers, who shall inform the competent authorities of suspicious orders and transactions.

(b) Provide for the seizure of any substance in Table I or Table II if there is sufficient evidence that it is used for the illicit manufacture of a narcotic drug or a psychotropic substance.

(c) Notify, as soon as possible, the competent authorities and services of the Parties concerned if there is any reason to believe that the import, export or transit of a substance in Table I or Table II is destined for the illicit manufacture of narcotic drugs or psychotropic

substances, including in particular information about the means of payment and other essential elements which led to that belief.

(d) Require that imports and exports be properly labelled and documented. Commercial documents, such as invoices, cargo manifests, customs, transport and other shipping documents shall include the names, as stated in Table I or Table II, of the substances being imported or exported, and the name and address of the exporter, the importer and, when available, the consignee.

(e) Ensure that documents referred to in sub-paragraph (d) of this paragraph are maintained for a period not less than two years and may be made available for inspection of the competent authorities.

10. (a) In addition to the provisions of paragraph 9, and upon request to the Secretary-General by the interested Party, each Party from whose territory a substance in Table I is to be exported shall ensure that, prior to such export, the following information is supplied by its competent authorities to the competent authorities of the importing country:

(i) Name and address of the exporter and importer and, when available, the consignee;

(ii) Name of the substance in Table I;

(iii) Quantity of the substance to be exported;

(iv) Expected point of entry and expected date of dispatch;

(v) Any other information which is mutually agreed upon by the Parties.

(b) A Party may adopt more strict or severe measures of control than those provided by this paragraph if, in its opinion, such measures are desirable or necessary.

....."

In the Annex to this Convention the following substances are listed:

"Table I	Table II
Ephedrin	Acetic anhydrid
Ergometrine	Acetone
Ergotamine	Anthranilic acid
Lysergic acid	Ethyl ether
1-Phenyl-2-propanone	Phenylacetic acid
Pseudoephedrine	Piperidine

The salts of the substances listed in this Table whenever the existence of such salts is possible."

This text shows that for the substances listed in Table I or Table II a domestic control programme in each participating country as well as an international control programme are required.

3.3 Comparison of the control of chemicals in the two Conventions

A comparison of the two Conventions shows that substances listed under Schedule 2 of the Convention on Chemical Weapons correspond to the ones listed in Table I of the Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, and those listed in Schedule 3 correspond to the ones listed in Table II. Substances listed in Table II include acetone, ethyl ether and acetic anhydride, which are produced and processed in large quantities in the chemical industry for many purposes.

Whereas in the Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances Trade in chemicals listed in Table II, i.e. common chemical intermediates, is closely monitored, the Convention on Chemical Weapons requires for chemicals listed in Schedule 3, i.e. common chemical intermediates, reporting of data concerning imports, exports, production and consumption on a national basis only. No monitoring of the trade of these chemicals is required, nor any control of the facilities producing or consuming them.

As defined in the rolling text of the Convention on Chemical Weapons the distinction between Schedule 2 and Schedule 3 chemicals is not only a question of importance for the production of chemical weapons or of toxicity. Precursors essential for the production of chemical weapons, but also used in large quantities for non-prohibited purposes, are subjected to a much less stringent control régime than chemicals which are of minor commercial importance. The regulations as proposed presently are obviously the result of a compromise between the requirements of the Convention and commercial interests at the expense of the effectiveness of the Convention.

In this connection it is interesting to note that in a recent Seminar on the Application of the 1988 United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, held in Brussels from 18 to 22 June 1990, the United States Department of Justice presented a report on the United States Experience with Essential/Precursor Chemical Control under the Chemical Diversion and Trafficking Act of 1988, which monitors the trade of 20 chemicals. No difficulties in the enforcement of these regulations were reported. Even in a chemical industry as large and diverse as that of the United States the burden of control is small.

A similar view is presented in comments of the United States Chemical Manufacturers' Association on Chemical Weapons Precursor Export Control before the United States Department of Commerce dated 29 February 1990.

In view of this evidence there appears to be no reason why similar national and international trade monitoring systems as required by the Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances should not be developed and adopted for the chemicals listed in Schedule 2 and Schedule 3 of the Convention on Chemical Weapons.

In fact, the Chairman of the Open-ended Consultations has also suggested that a national materials balance for declared chemicals should be considered. In his report on National Trial Inspections, CD/CW/WP.248/Rev.1 he states:

"11. Types of records needed and/or audited

Quantitative data would be needed for the establishment of a 'national material balance' for a declared chemical. Such a balance might give an indication of whether diversions were taking place, whereas no conclusion on possible diversions could be drawn from the inspection of a single facility. Facility records auditing may help in reaching a judgement about the level of assurance of the facility's activity. However, this auditing might only prove that declarations were consistent, not necessarily that they were accurate ....."

But there has been no apparent follow-up of this very important suggestion.

There is only one difference between the objectives of the two Conventions: in the Convention Against Illicit Traffic in narcotic Drugs and Psychotropic Substances the control is directed against the illicit use of certain chemicals by private parties, whereas in the Convention on Chemical Weapons it is directed against the illicit use by certain governments. But there are important and far-reaching similarities between the problems of control of chemicals essential for the production of narcotic drugs and of chemical weapons. There is no apparent reason for establishing different control mechanisms in the two Conventions.

It is interesting to note at this point that although not discussed up to now on an international level the transboundary traffic of dangerous waste materials poses similar problems of control. Here, too, it will be necessary to establish an international monitoring system which prevents the misuse of certain waste materials.

4. Proposal for monitoring system for chemicals

It so appears that for the control of narcotic drugs, the control of chemical weapons proliferation, but also for possible other similar requirements in the future a monitoring system for certain chemicals should be established.

Requirements for such a system are

- general applicability
- effectiveness
- unobtrusiveness
- international operation
- low cost.

The following discussion is intended to propose the outlines of such a system with due regard to the provisions of the rolling text of the Convention on Chemical Weapons.

As mentioned above Article VI of the Convention on Chemical Weapons requires each State Party:

- to establish a domestic control régime (Art. VI (1) (b)); and

- to subject toxic chemicals listed in Schedules 1, 2 part A, 2 part B and 3, as well as facilities which produce, process or consume these toxic chemicals or precursors to international monitoring (Art. VI (2)) and international on-site inspection (Schedule 2 chemicals only, Art.VI (6)).

This can be read to mean that three interlocking control régimes should be established for the chemicals listed in Schedule 2 and 3:

- a facility control régime;)
- a national control régime;) forming together the domestic control régime

- an international control régime.

Aim of the facility control régime should be to ensure

- that the facility is not used to produce any chemical listed in Schedule 1

- the quantities of chemicals listed in Schedule 2 produced, processed or consumed are consistent with needs for purposes not prohibited by the Convention;

- the chemicals listed in Schedule 2 are not diverted or used for purposes prohibited by the Convention (Annex to Art. VI (4) (i) to (iii)).

Aim of the national (domestic) control régime should be to provide the information necessary for the Initial Declaration, the Annual Declaration and the Advance Notification required by the provisions of Annex 2 to Article VI paragraphs (1) to (3) and to monitor the internal national trade, as well as exports and imports.

Aim of the international control régime should be to process the data supplied by the State Parties in their Annual Declarations and Advance Notifications and to check their plausibility.

Responsibility for the domestic control rests with the national authorities, that for the international control with the Technical Secretariat for the Convention on Chemical Weapons, but it would be possible to countercheck the reports from the various State Parties against each other.

As can be readily realized the basis for the national and for the international control régimes is the facility control régime as the latter are based on the data of the former. So the primary effort must be directed towards developing a facility control régime that is generally applicable, requires a minimum of effort and no undue intrusion into the internal affairs of the company concerned, but assures a maximum of confidence in its results.

5. Means for implementing a facility control régime

In order to achieve the requirements mentioned above it is suggested to establish an effective facility control régime based on auditing various company records by a computerized procedure. The application of a computer program can avoid time consuming manual calculations and is suitable for the processing of a large number of records in a short time.

Records produced by the company would list quantities produced and/or consumed as well as all shipments into the facility and out of the facility of the chemical under investigation. These records would be collected and checked by a national authority and form the basis for establishing a national materials balance for this chemical, showing aggregate production, export and import data only. Any inconsistencies in the reports from the facilities would show up at this level.

The combined national records should be collected by the Technical Secretariat of the Convention and would provide the basis for a global materials balance, again showing any inconsistencies in the national annual declarations.

By using internationally standardized forms for the various reports, which should be suitable for machine reading, a minimum of time would be necessary for the verification of the non-diversion of any Schedule 2 or Schedule 3 chemical.

A similar computer program should be developed for inspection purposes:

The inspection team would bring with it a lap top type computer and the program to be used for auditing and checking the records available. The input into the program should consist of three types of information:

- information relating to the particular facility;

- information relating to the particular chemical; and

- information relating to the period under investigation

Facility related information that is considered confidential by the company can be stored on a diskette which could remain under dual lock at the facility; the same is true for any information about the particular chemical and the production process under consideration. Various records available at the facility for the period under investigation would form inputs into the program as would the facility and the chemical related information.

After having received all inputs the computer would perform a check as to the consistency of the data by using a number of techniques to be described; it would print out only inconsistencies giving date and type of inconsistency. The inspection team would take out of the plant only this record of inconsistencies - if any - and none of the plant data, so all problems of confidentiality could be avoided.

A program usable on lap top computers has been worked out and is available to interested parties.

Alfred Schmidt
Peter J. Holzer

DEVELOPMENT OF A COMPUTER PROGRAM FOR ACCOUNTS AUDITING DURING INSPECTIONS OF FACILITIES

Considerable efforts during the negotiations of the Convention on Chemical Weapons were conducted towards assuring an effective verification of non-production of chemical weapons through on-site inspection. General rules governing inspections were worked out as the importance of this aspect was recognized (CD/1033, Addendum to Appendix I, pp. 148-184).

According to Article VI of the proposed Convention each State party has initially to prepare and present a list of facilities which, during any of the previous three calendar years, produced, processed, or consumed more than 1 ton of chemicals listed in Schedule 2, Part A. Relevant non-prohibited activities of the chemical industry are verified by way of graded verification régimes subjecting chemicals listed in Schedules and the facilities producing or consuming such chemicals to systematic international on-site verification on a routine basis.

The following types of verification measures were considered:

- routine inspections
- ad hoc inspections
- challenge inspections.

During the negotiations interest shifted from routine to challenge and ad hoc inspections. At present no final agreement has been reached on this matter.

The Chairman of the Ad hoc Committee on Chemical Weapons invited interested States to undertake national trial inspections and issued a working paper on this subject (CD/CW/WP.213). This paper was primarily intended to assist in the preparations for national trial inspections. The main emphasis of the trial inspections was directed towards analytical detection of Schedule 1 chemicals, but other checking methods were also suggested.

One of these non-analytical methods is auditing the facility's materials and financial accounts. Section B (11) of this working paper contains a list of:

"Types of records needed and/or audited

- plant production records
- production process records
- records on chemicals produced

- plant information

- utility/financial statements".

In a later review of the reports of 17 national trial inspections (CD/CW/WP.248/Rev.1) by the Chairman of the Open-ended Consultations, more weight is placed on the types of records needed and/or audited and a number of useful suggestions are made:

"11. Types of records needed and/or audited

Auditing of records would form a major part of an inspection. Furthermore, the confidence in the inspection results would be greater, the larger the number and types of records used. Some data in the records, which were extremely sensitive, had not been made available during some national trial inspections.

Quantitative data would be needed for the establishment of a 'national material balance' for a declared chemical. Such a balance might give an indication of whether diversions were taking place, whereas no conclusion on possible diversions could be drawn from the inspection of a single facility. Facility records auditing may help in reaching a judgement about the level of assurance of the facilitity's activity. However, this auditing might only prove that declarations were consistent, not necessarily that they were accurate ...

A comprehensive quantity control extending beyond the inspected facility could prove useful."

No further comments are made to this point; this fact shows that the main interest during facility inspections was directed towards analytical procedures.

In a recent Report on the Second United States Trial Inspection (CD/18 June, 1990, pp.17/18) other interesting remarks and suggestions are made:

"Chemical production practices generate a multitude of interlocking records that can be audited as a means of monitoring declared chemical production ... The alternative was to go to the daily plant log sheets and other daily records and reconstruct what took place in the reactor 3MR for the entire year. Another related issue was that the Company produces two chemicals, thiodiglycol and 2ME, from the same raw materials. This meant that both materials had to be totally accounted for to verify declared thiodiglycol production ... This resulted in more effort than planned which was resolved by enlisting several of the observers to participate in the auditing process ... Another area of concern is the ultimate disposition of high risk Schedule 2 chemicals. Thiodiglycol is one step away from mustard agent. The routine inspection will only examine and calculate quantities declared and produced in a given period. It provides no information on the distribution and subsequent use of this chemical. To effectively achieve the treaty objective of detecting prohibited use of thiodiglycol, it would seem that the tracking of this chemical to its ultimate destination should be part

of the inspection procedure. This would increase the intrusiveness of the inspection but seems warranted for certain listed chemicals, such as thiodiglycol. Tracking the distribution would create additional burdens for the Technical Secretariat to trace the shipments to their destinations ...".

It thus appears that as a result of the national trial inspections it was realized that the auditing of various records could be an effective means for the verification of non-production not only in a certain facility, but also on a national and on an international level, but its actual performance would be difficult and time-consuming.

2. Requirements for records auditing during inspections.

In order to avoid the difficulties mentioned above, facility inspection based on auditing various company records requires a computerized procedure. The application of a computer program can avoid time-consuming manual calculations and is suitable for the processing of a large number of records in a short time.

The inspection team would bring with it a lap top type computer and the program to be used for auditing and checking the records available. The input into the program should consist of three types of information:

- information relating to the particular facility;
- information relating to the particular chemical; and
- information relating to the period under investigation.

Facility related information that is considered confidential by the company can be stored on a diskette which could remain under dual lock at the facility; the same is true for any information about the particular chemical and the production process under consideration. Various records available at the facility for the period under investigation would form inputs into the program as would the facility and the chemical related information.

After having received all inputs the computer would perform a check as to the consistency of the data by using a number of techniques to be described; it would print out only inconsistencies giving date and type of inconsistency. The inspection team would take out of the plant only this record of inconsistences - if any - and none of the plant data, so all problems of confidentiality could be avoided.

3. Description of the computer program

Many chemicals can be produced using the same raw materials and facilities used for the production of standard chemicals for commercial use. To verify the non-production of chemical weapons, on-site inspections of production facilities are necessary. These on-site inspections will consist of:

- inspections of the technical installations of the facility,

- taking various samples of materials in the plant area for chemical analysis, and of

- auditing various plant records for a certain period.

The program to be described aids in auditing the records by simulating the plant for this period.

3.1 The plant model

From an external point of view, a chemical facility purchases chemicals, converts them into other chemicals and sells them. The plant itself consists of a number of stores and reactors. Suppliers, customers and waste dumps can in fact be viewed as additional stores of the plant. This leads to five classes of locations in the plant:

Customers and wastes dumps receive chemicals from other locations but never deliver to other locations. We are not interested in the kinds or quantities of chemicals in these locations.

Suppliers deliver into internal stores but receive nothing. Because the supplier expects money for the chemicals supplied, getting chemicals from them is more complicated than from other locations and follows a fixed procedure:

- by comparing production plans and stocks the requirements are identified;

- offers (bids) from various suppliers are invited and obtained;

- chemicals are ordered from a supplier;

- the chemicals are delivered and put in stock.

We are not interested in the kinds or quantities of chemicals in these locations.

Internal stores are used to store temporarily chemicals received from suppliers or reactors before they are used in reactors or sold to customers. Therefore, they both deliver and receive chemicals, and because they are inside the plant being simulated we can determine and check their inventory at any moment.

Reactors receive chemicals from internal stores, then a reaction takes place converting these chemicals into others which are then delivered to internal stores or to waste dumps.

Others: For special purposes (e.g. carry-over from previous periods) it can be useful to have locations on which no checks are performed.

Transactions are a static description of the plant and its environment. To simulate the plant over a given period of time, we need to describe the changes that happen to the locations in the course of time. This is done by transactions.

Flow transactions describe the flow of a chemical from one location to another.

Reaction transactions describe the reactions taking place in a reactor.

Additional transactions do not describe actual changes in the plant but are used to identify inconsistencies in the data to be audited.

Requirements, offers, orders are bureaucratic transactions which precede flows from a supplier to an internal store. In the real world their purpose is to organize the exchange money/goods and to minimize costs. This purpose is irrelevant to the model, but we know that for each flow from a supplier a corresponding order, offer (bid) and requirement must exist, so they can be used to identify faked flow transactions.

Empty transactions are pseudo-transactions to check whether a location is empty.

Given the locations and the transactions mentioned, the plant is simulated by the program over the period in question and various checks are performed on the data:

- at no time a location may have a negative inventory;
- on an "empty" transaction the location indicated must be empty;
- for each "flow" transaction from a supplier to an internal store an "order" transaction with identical chemical and quantity from an earlier date must exist;
- for each "order" transaction a corresponding "offer" transaction with earlier date must exist;
- for each "offer" transaction a corresponding "requirement" transaction with earlier date must exist;
- no "flow" transaction may have a customer as source;
- no "flow" transaction may have a supplier as destination;
- "reactions" may only take place in reactors;
- no "flow" transactions between suppliers, customers and reactors may exist.

2.2 Files

Any information necessary for the performance of the program is entered via various files.

Reaction database is used to define the chemical reactions taking place in the facility. Each reaction is defined by its name, its raw materials, its products and the corresponding yields.

The yields of chemical reactions can be determined by stoichiometric calculations; so the quantitative relations between the various chemicals involved in a reaction are known.

In industrial practise actual yields do not follow the exact figures calculated, the yield of a reaction can be a range of values instead of a single fixed value. To allow for this fact, an upper and a lower yield factor can be assumed and introduced into the program files.

Location database defines the existing locations with the name and the type of location and is grouped accordingly:

customer

supplier

internal

reactor

other.

Transaction file contains one line for each transaction. The lines have the following format:

requirement	date	chemical		
offer	date	chemical	from	
order	date	chemical	from	
flow	date	chemical	from	to
empty	date	location		
reaction	date	location	reaction	

2.3 Program operation

The program package prepared consists of two programs called enter_tr.exe and stoche.exe and the data files mentioned above.

Enter_tr.exe is a program to enter transactions.

Stoche.exe takes a transaction database, a reaction database and a location database and checks them for consistency. The checks described above are performed on the data.

If the data are consistent the program remains quiet; any inconsistencies yield a message explaining what is wrong and after which transaction the inconsistency was identified.

In addition a few rough checks are performed on the reaction database:

- the sums of the raw materials consumed by a reaction and its products must be equal;

- if ranges are used to specify yields, the minimum yield must be smaller than the maximum yield.

If this is not the case a diagnostic message is printed.

The program package is available for interested parties on 5-inch or on 3.5-inch floppy disks together with a users' guide and a maintenance guide.

A PROGRAM FOR CHECKING STOCK RECORDS FOR CONSISTENCY

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Abstract

The Convention on Chemical Weapons provides different means for verifying that its members do not produce chemical weapons. One of them is the on-site inspection of production plants to verify that the plant used materials and installations which could be used to produce chemical weapons for permitted purposes only.

This paper presents a program for checking the stock and production records for inconsistencies. It consists of three sections. The first describes how the program works, what data it uses, and what checks it does perform on the data. The second section is a user's manual and shows how to use the two parts of the program. The last section is a maintenance guide for those who want to add additional checks to the program or port it to different hardware.

1. SCOPE OF THE PROGRAM

Many chemical weapons can be produced using the same raw materials and installations as used for production of standard chemicals for commercial use. To verify the non-production of chemical weapons on-site inspections of production plants at short notice are necessary. This on-site inspection will consist of inspections of the technical installations of the plant, checking the stock against the records and of auditing of the production and stock records for a certain period. StoChe aids on the last task by simulating the plant for this period.

1.1 The plant model

From an external view a chemical plant purchases chemicals, converts them to other chemicals and sells them. The plant itself consists of a number of stores and reactors. Suppliers, customers and waste dumps can in fact be viewed as additional stores of the plant. This leads to five classes of locations in our model:

1.1.1 Locations

Customers and waste dumps receive chemicals from other locations but never deliver to other locations. We are not interested in the kinds of quantitites of chemicals in these locations.

Suppliers deliver to internal stores but receive nothing. Because the suppliers want money for their chemicals, getting chemicals from them is more complicated than from other locations and follows a fixed procedure:

1. By comparing production plans and stock the requirements are ascertained.

2. Offers from various firms are obtained.

3. Chemicals are ordered from one of the firms.

4. The chemicals are delivered and put in stock.

We are not interested in the kinds of quantitites of chemicals in these locations.

Internal stores are used to store temporarily chemicals received from suppliers or reactors before they are used in reactors or sold to customers. They therefore both receive and deliver chemicals, and because they are inside the plant being simulated we can determine and check their inventory at any moment.

Reactors receive chemicals from internal stores, then a reaction takes place converting the chemicals in the reactor to others which are then delivered to internal stores or waste dumps.

Others for special purposes (e.g. carry-over from the previous period) it might be useful to have locations on which no checks are performed.

The locations are a static description of the plant and its environment. To simulate the plant over a period of time we need to describe the changes that happen to the locations during that time. This is done by transactions.

1.1.2 Transactions

Flow transactions describe the flow of a chemical from one location to another.

Reaction transactions describe the reaction taking place in a reactor.

Additional transactions do not describe actual changes in the plant but can be used to find inconsistencies:

Requirements

Offers

Orders are bureaucratic transactions which precede flows from a supplier to an internal store. In the real world their purpose is to organize the exchange money/goods and to minimize the cost. This purpose is irrelevant to the model, but we know that for each flow from a supplier a corresponding order, offer and requirement must exist, so they can be used to find faked flow transactions.

Empty transactions are psuedo transactions to check that a location is empty.

1.1.3 Checks

Given the locations and the transactions the plant is simulated over the period in question and various checks are performed:

- At no time may a location have a negative inventory;
- On an "empty" transaction, the indicated location must be empty;
- For each "flow" transaction from a supplier to an internal store an "order" transaction with identical chemical, quantity and from field and earlier date must exist;
- For each order transaction a corresponding offer- transaction with earlier date must exist;
- For each offer transaction a corresponding requirements- transaction with earlier date must exist;
- No flow transaction may have a customer as source;
- No flow transaction may have a supplier as destination;
- Reactions may only take place at reactors;
- No flow transactions between suppliers, customers and reactors may exist.

1.1.4 Variable yields in reactions

Unfortunately, real industrial processes do not follow the exact rules that are found in chemistry books and may be affirmed in small-scale laboratory experiments. For a given reaction in a known environment you cannot determine the yield more accurately than to a few per cent. To allow for this fuzziness, the yield of a reaction can be a range of values instead of just a single value for each product. Of course the effects of repeated reactions with fuzzy output will accumulate so the ranges should be as tight as possible to permit proper checking.

2. USER'S GUIDE

The program package consists of two programs called enter_tr.exe and stoche.exe and a number of data files.

2.1 Enter-tr.exe

Enter_tr is a program to enter transactions. New transactions are entered in forms and transactions entered at a prior date can be edited.

[F1] - Help not yet implemented.

[F3] - Quit Leave Program without updating the transaction data base.

[F4] - File Update the transaction data base and leave the program.

[F5] - Flow Enter a flow transaction.

Date - Date of the transaction: Dates are free form strings used to sort the database. To achieve proper ordering you should enter it in the form YY_MM_DD_HH:MM:SS. Note that spaces are not allowed in this prototype. Use underscores instead (the final version will support spaces if it proves to be necessary).

Chemical - Which chemical is moved from one location to another.

Quantity

From - How much of this chemical is moved. Remember that all quantities must be entered with the same unit. Mixing litres and kilograms and tons may produce meaningless results (at the very least, the reaction data base check will fail).

To

[F6] - Reaction Enter a reaction transaction.

Date

What - The reaction taking place.

Where - The location where the reaction takes place.

[F7] - Empty Check location for zero inventory.
Enter this transaction if you want to check if at a given date a location is empty.

Date

Location

[F8] - Order Enter an Order.

Date

Chemical

Quantity

From

[F9] - Offer Enter an Offer.

Date

Chemical

Quantity

From

[F10] - Requirement Enter a Requirement.

Date

Chemical

Quantity

[PgUp] Edit previous transaction

[PgDn] Edit next transaction. This does only work if the next transaction does exist. If not, nothing happens and you can enter the next transaction using |F5|-|F10|.

In the forms the following keys have special meaning:

[Carriage Return] or [Enter] Accept the current field and go to the next field. If pressed in the last field of a form the entre form is accepted.

[Esc] Leave the form: the contents are not updated.

[Left Arrow] and [Right Arrow] Move the cursor.

[Up Arrow] and [Down Arrow] Accept the current field and move to the previous/next field.

[Backspace] Delete the character left of the cursor.

[Del] Delete the character under the cursor.

[Ins] Toggle between insert and overwrite mode.

2.2 StoChe

StoChe takes a transaction data base transactions.dat entered with enter_tr or any text editor and a reaction and location database (reactions.dat and locations.dat) and checks them for consistency. If the data are consistent it should remain quiet, but any inconsistencies yield a message explaining what is wrong and after which transaction the inconsistency was found.

The checks described in section 1.1.3 are performed on the data. In addition to these checks a few rough checks are performed on the reaction database:

- The sums of the raw materials consumed by a reaction and the products yielded by it must be equal.

  For reactions with varying output this means that the input must lie between the minimum and maximum yield.

- If ranges are used to specify variable output, the minimum yield must be smaller than the maximum yield. If this is not the case the two numbers are exchanged and a diagnostic message is printed.

The following command line arguments will produce additional output:

dumplines prints all lines read from the databases as the program proceeds;

dumplocations prints the inventories of all locations after each transaction;

dumpreactions prints the contents of the reaction database after it has been read;

paranoid prints warnings about negative inventories not only when the inventory is definitely negative but also when the inventory may be negative.

2.3 File formats

All files used by StoChe are ordinary text files. Normally items are separated by whitespace (space, tab, and newline). If an item contains spaces (e.g. liquid oxygene), it has to be enclosed in double quotes ("liquid oxygene").

2.3.1 Reaction database

Each reaction is defined by an entry of the following form:

```
Reaction - Name
           raw_materials
              raw_material1 quantity1
              raw_material2 quantity2
              ...

           products
              product1 lower1 upper1
              product2 lower2 upper2
```

The indentation is optional (but should be used for lucidity), the line breaks are mandatory. If lower and upper are the same for a product (which means that the yield is exactly known for this reaction) upper can be omitted.

2.3.2 Location database

The location database contains one line per location with the name and type of the location. The location types are described in detail in section 1.1.1.

If the type of the location is not specified it is assumed to be of type other.

Locations not defined in the location database but used in the transaction file are created on the fly with type internal.

2.3.3 Transaction file

The transaction file contains one line for each transaction.

The lines have the following format:

```
requirement     date        chemical
offer           date        chemical     from
order           date        chemical     from
flow            date        chemical     quantity   from      to
empty           date        location
reaction        date        location     reaction
```

2.4 Format files

The screeen masks in enter_tr are described by form files. These are the files ending in .frm. Their format is described in detail in section 3.3.2.

2.5 A short example

As an example, consider a plant which produces two chemicals P_1 and P_2 out of three raw materials R_1, R_2 and R_3. To produce 1 ton of P_1 we need 800 kg of R_1 and 300 kg of R_2. The second reaction is not quite as straightforward: using 500 kg of R_1 and 1,000 kg of R_3 we get 1,200-1,240 kg of P_2 and 260-300 kg of wastes. So use your favourite text editor to produce a file reactions.dat:

```
#
# This describes the reaction which produces p1
#
reaction make_p1
     raw_materials
          r1          800
          r2          300
     products
          p1        1,000

#
# And this reaction produces p2
# Note the variable yield.
#
reaction make_p2
     raw_materials
          r1          500
          r3        1,000
     products
          p2        1,200 1,240
          waste       260   300
```

Now that we have set up our reaction database we take a look at the plant: it has two stores, one for the raw materials and one for the products (before they are shipped to the customers). Both reactions take place in the same reactor, and all three raw materials are purchased from the same supplier, ACME, Inc. So we need the following locations in our locations database location.dat:

```
acme      supplier
store.in  internal
store.out internal
reactor   reactor
```

Of course our plant should also sell some of the chemicals it produces (to prevent it from going bankrupt), so we have to invent a few customers as well. Let us call them C_1 and C_2 (not very original, I know).

Also it already had chemicals on stock at the start of the observation period. But StoChe does not provide a means for an initial stock at a location. Fortunately this can be easily accomplished: We just have to define a location carry of type other, from which we can load our initial stock.

So we need three additional locations:

```
C1     customer
C2     customer
Carry other
```

Now we are ready to enter all the transactions during the observation period.

Start enter_tr. First we will enter five pseudo-moves to get the initial stock: Press |F5| and fill in form as follows:

Transaction	
Date	90-01-01
Chemical	r1
Quantity	20000
From	carry
To	stock.in

In the same way move 24 tons of R_2 and 14 tons of R_3 from carry to stock.in and 4 tons and P_1 and 7 tons of P_2 from carry to stock.out.

Now, on 3 January we want to produce 10 tons of P_1, so we move 8 tons of R_1 and 3 tons of R_2 from stock.in to reactor and start reaction make_p1 (with [F6]):

Reaction	
Date	90-01-03
Which	make_p1
Where	reactor

and after we moved the 20 tons of P_1 to stock.out we check if the reactor is now really empty ([F7]):

Empty	
Date	90-01-03
Where	reactor

On the next day somebody discovers that too little of R_1 and R_3 is on stock, so he files a request for 10 tons of R_1 ([F10]):

Requirement	
Date	90-01-04
Chemical	r1
Quantity	20000

and for 20 tons of R_3. Two days after this an offer from ACME, Inc. is received and the day after the chemicals are ordered from ACME. They arrive on 7 January and on 10 January production of P_2 starts by moving 12,300 kg R_1 and 24,600 kg R_3 to the reactor and starting the reaction make_p2. On 12 January the reaction has completed and 30 tons of P_2 are moved to stock.out and 7 tons of wastes are moved to carry (Carry being our "dont't-care"-location). On 5 January 12 tons of P_1 were sold to customer C_1.

If you exit enter_tr now and look at transact.dat it should look as shown in figure 1 (without the comments). Note that the last flow transaction you entered (dated 90-01-05) was moved to the correct position.

If you start stoche now, the output will be as shown if figure ??... While checking the reactions it notes that in reaction make_p1 the raw materials and products do not have the same mass. So maybe this reaction should be checked again. For transaction 32 (flow 90-01-12 waste 7,000 reactor carry) it notes that this is a mass flow between two non-internal stores which is doubtful (we know of course that we do not care about what flows in and out of carry, so we can ignore this warning). Finally the program states that at the end of the observation period no open requirements, offers and orders existed and prints the contents of the various locations: Reactor is empty (as it should be when nothing is produced, and the stocks for stock.in and stock.out can be compared to their real contents (they should match).

3. MAINTENANCE GUIDE

3.1 StoChe

Stoche was written with portability in mind. It operates on text files and has been run successfully both on MS-DOS and UNIX systems. It does not use any functions not defined in the ANSI C standard.

It consists of the following files:

stoche.c contains the main loop and new-chemical, which is used by react_db.c and trans_f.c.

react_db.c contains the function for manipulating the reaction database: new_reaction, read_reaction-db, dump_reaction_db, check_reactions.

location.c contains all functions for manipulating the location database: new_location, get_check-s, dump_location_db, check_locations, is empty, read_reaction_db.

trans_f.c contains the functions needed for processing the transaction file: do_move, do_requirement, do_offer, do_order, do_reaction, dump_open_requirements, dump_open_offers, dump_open_orders, read_transaction file.

lists.c contains functions for manipulating lists, used by all other modules: insert, find.

The two header files stoche.h and stoche_t.h are used by both StoChe and enter_tr.

3.1.1 Localization

To aid localization of the program all the messages (except internal errors like "out of memory") are in a separate message file stoche.msg. You can change these messages to your needs (other national language, different technical terms, other tastes in formatting output, ...) without recompiling the program. The file contains one string per line and a comment telling you the variable name used for this string in the program. Note that you must not change the order of the strings or delete strings in the message file unless you chang read_msg in stoche.c. Note, however, that changing the strings empty_s, flow_s, loc.reactor_s, loc_internal_s, loc_customer_s, loc_supplier_s loc-other_s, location_s, offer_s, order_s, prod_s, rawmat_s, reaction_s, requirement_s changes the format of the input files. This means that you have to change enter_tr and all old input files you still want to use accordingly.

3.2 EnterTr

Because EnterTr is not really needed for using StoChe, but is merely a tool that allows more convenient entry of transactions than a text editor, portability was not as important as fast screen updates. Because of this I used my public domain tWin package to handle the I/O instead of relying on stdio or a widely known screen manager like curses 1/. This decision might cause problems if the program is to be ported to another computer or just another compiler.

3.3 tWin

TWin is a small public domain text window library. It writes directly into the video memory of the PC, so it is reasonably fast, but porting it to other architectures might cause problems.

Another problem that might arise is that on older CGA cards (especially those made by IBM) video memory may only be accessed during vertical or horizontal retrace. On such displays snow will appear every time the screen is updated.

3.3.1 winit.rc

Winit.rc is a configuration file for the tWin library. It is read every time winit () is called. At the moment two parameters can be specifieid:

1/ Although curses is reasonably fast, I do not like it very much. I am not sure if this is the fault of the curses concept or caused by the fact that I have never seen a bug-free implementation.

Insertcursor specifies the shape of the cursor in insert mode. The shape should be given as a C hexadecimal number. If you want the cursor to start at the seventh scan line and extend to the fourteenth scan line the line should read insertcursor 0x070E. The top line of each character is line 0, the bottom line is 7 on a CGA, 13 on a MDA, Hercules, or EGA, and 15 on a VGA. Note that many EGA and VGA cards provide additional text modes. If you use one of these, see the manual of your video card to find out how many scan lines they use per character.

Overwritecursor specifies the shape of the cursor in overwrite mode the same way as insertcursor.

3.3.2 Form files

In tWin a form is a window with text and entry fields. It is described by a so-called form file which has the following format:

One line describing the window:

window [size width height] [orig x y] [text text] [attrib attrib]

followed by one line for each field:

field [size width height] [orig x y] [text text] [attrib attrib] [perm perm]

Note that although the description fields for both windows and fields are all optional and can appear in any order, it is not advisable to leave any of them out. The default values do not make much sense.

Figure 1: An example transaction database

```
# stock at start of observation period
flow 90-01-01 r1 20000 carry stock.in
flow 90-01-10 r2 24000 carry stock.in
flow 90-01-01 r3 14000 carry stock.in
flow 90-01-01 p1  4000 carry stock.out
flow 90-01-01 p2  7000 carry stock.out
# produce 10 tons of p1
flow 90-01-03 r1 8000 stock.in reactor
flow 90-01-03 r2 3000 stock.in reactor
reaction 90-01-03 make_p1 reactor
flow 90-01-03 p1 10000 reactor stock.out
empty 90-01-03 reactor
# we need more chemicals for producing P2
requirement 90-01-04 r1 10000
requirement 90-01-04 r3 20000
# in the meantime we sell some of our p1 to c1
flow 90-01-05 p1 12000 stock.out c1
# we get a good offer from acme
offer 90-01-06 r1 10000 acme
offer 90-01-06 r3 20000 acme
# so we order the same day
order 90-01-06 r1 10000 acme
order 90-01-06 r3 20000 acme
# the day after we get the stuff (acme is real fast)
flow 90-01-07 r1 10000 acme stock.in
flow 90-01-07 r3 20000 acme stock.in
# produce 30 tons of p2
flow 90-01-10 r1 12300 stock.in reactor
flow 90-01-10 r3 24600 stock.in reactor
reaction 90-01-10 make _p2 reactor
flow 90-01-12 p2 30000 reactor stock.out
flow 90-01-12 waste 7000 reactor carry
# we don't care about wastes
empty 90-01-12 reactor
```

Figure 2: Example Output from StoChe

```
-----CHECK of reactions-----
unbalanced quantities in reaction make_p1:
raw_materials; 1100, products: 1000 ... 1000
FLOW BYPASSES INTERNAL STORE!
---DUMP of open requirements ---
---DUMP of open offers ---
---DUMP of open orders ---

----- DUMP of locations -----
location acme (check = supplier)
location c1 (check = customer)
location c2 (check = customer)
location carry (check = other)
location reactor (check = reactor)
     P1 0 ... 0
     p2 -480 ... 504
     r1 0 ... 0
     r2 0 ... 0
     r3 0 ... 0
     waste -604 ... 380
location stock.in (check = internal)
     r1 9700 ... 9700
     r2 21000 ... 21000
     r3 9400 ... 9400
location stock.out (check = internal)
     p1 2000 ... 2000
     p2 37000 ... 37000
```